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Innovative pulse and cereal-based food fermentations for human health and sustainable diets

Utilising the potential of oats through fermentation technology

Arno G.B. Wouters, Ewoud Blontrock, Eline Lambrechts, Frederik Janssen, Celine Verdonck, Yamina De Bondt, Christophe M. Courtin

Laboratory of Food Chemistry and Biochemistry (LFCB) and Leuven Food Science and Nutrition Research Centre (LFoRCe)

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Co-funded by the European Union

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Oat composition

Carbohydrates (47-75%)
- Starch
- Saccharides
- Dietary fibres
  - β-glucan
  - Arabinoxylan

Proteins (10-17%)
- Globulins
- Albumins

Lipids (4.2-8.9%)
- Triacylglycerol:
  - Unsaturated fatty acids
- Phospholipids
- Glycolipids

Minor constituents
- Vitamins
- Minerals
- Polyphenols

Alemayehu et al. (2023), Mao et al. (2021), Klose & Arendt (2012)

Challenges in oat-based (liquid and semi-solid) foods

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Texture & stability (dairy alternatives)

- Sedimentation
- Creaming
- Viscosity

Nutritional limitations

- Poor extractability
- Antinutrients

Flavor issues

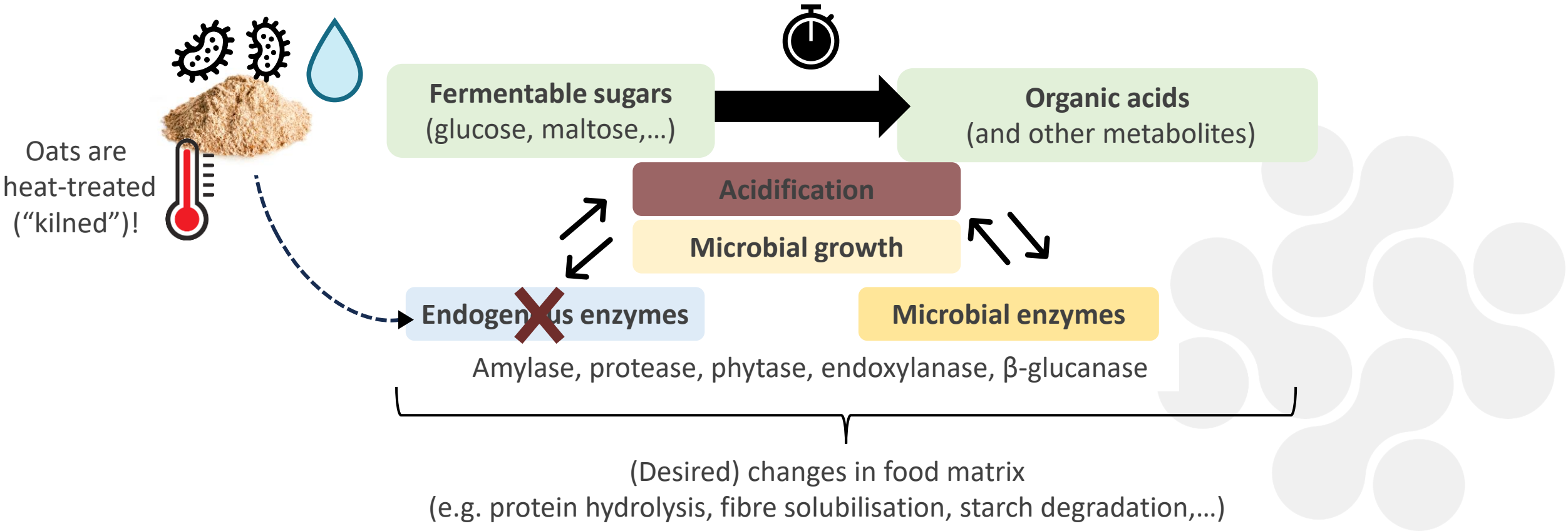
- Bitterness
- Off-notes by rancidity (lipids)
  - Kilning!

Opportunity for fermentation technology?

Li et al. (2025), Yang et al. (2023), Asschemann-Witzel et al. (2020), Montemurro et al. (2021)

Oat fermentation

"Foods made through **desired microbial growth** and **enzymatic conversions** of food components (ISAPP, 2021)"



Gobbetti & Gänzle, 2023; Gänzle, 2014; Gänzle et al. 2008; Arte et al. 2015

Research questions

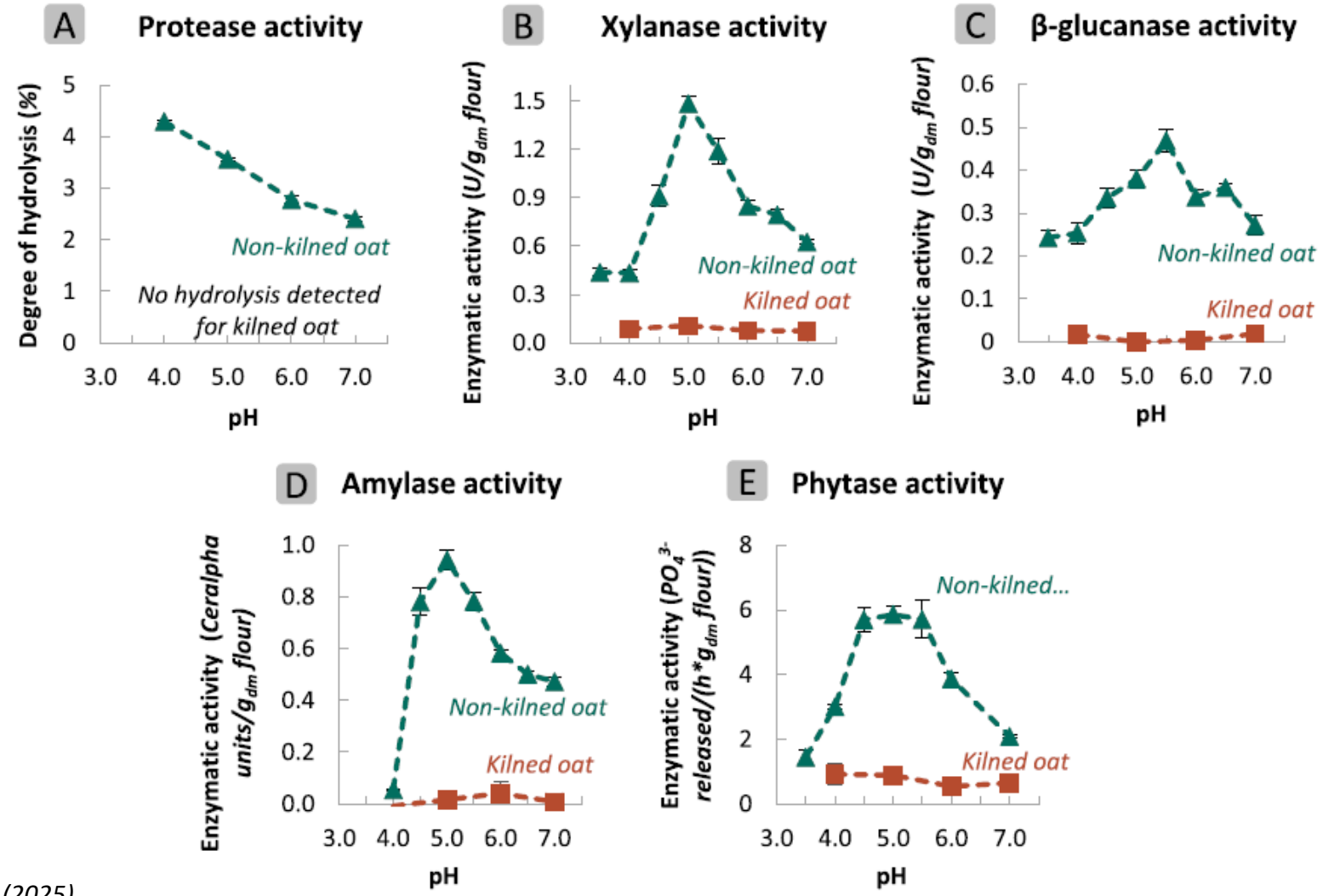
Oat enzymes and fermentation – What is the contribution of oat endogenous enzymes to the fermentability of oats?

Mitigating kilning – Can we overcome the effect of kilning on the oat endogenous enzymatic system in the context of acidic food fermentation?

Oat fermentation and technofunctionality – What is the effect of acidic food fermentation on the technofunctional performance of an oat drink model food?

Oat enzymes and fermentation

- pH-dependent enzymatic activities of kilned and non-kilned oats



Main findings:

- As expected, kilning largely inactivates the oat endogenous enzymatic system
- Carbohydrate and protein degrading enzymes have higher activities at pH values relevant for acidic food fermentations

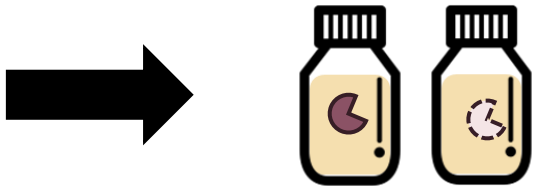
Blontrock et al. (2025)

Oat enzymes and fermentation

- Fermentability of (non-)kilned oat suspensions: Experimental set-up

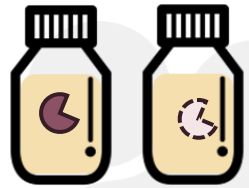
Kilned (K) and non-kilned (NK) **defatted oat wholemeal** (DOW)

+ sterile water (1:6 w/v ratio)



NK or K defatted oat flour **suspensions**

+ L. plantarum (Chr. Hansen / Novonesis, DK)
30°C
0, 0', 2, 4, 8, 12, or 24 h



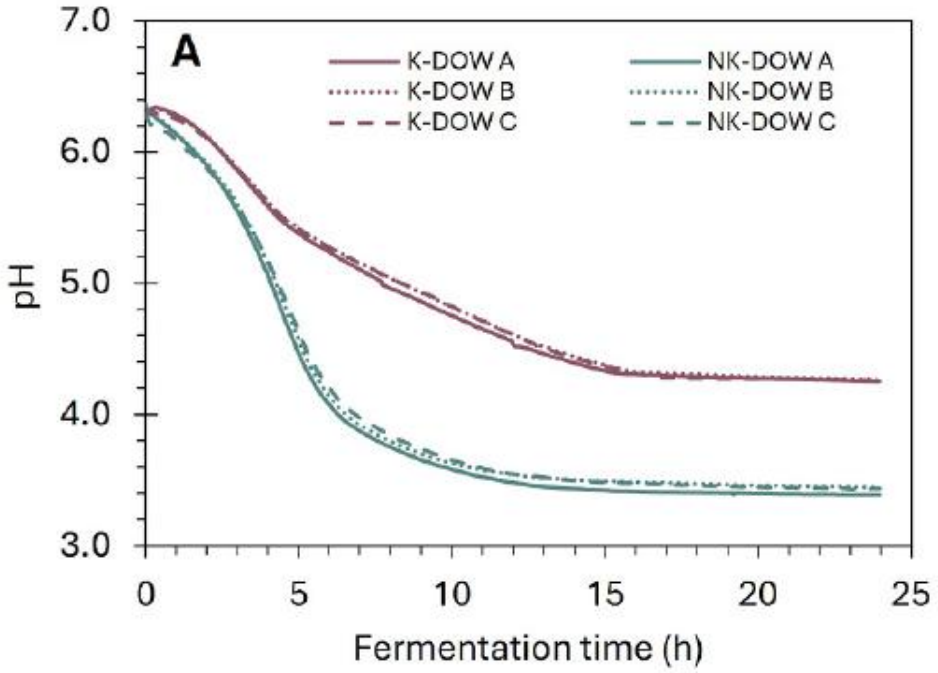
Fermented suspensions at different time points

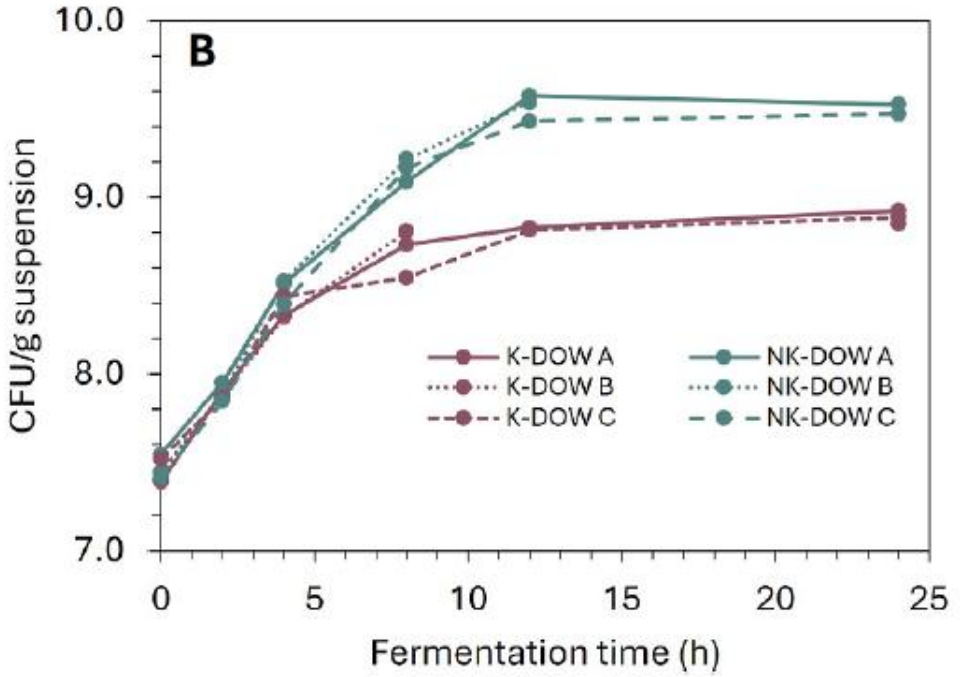
Acidification
Microbial growth
Lactic acid production
Fermentable sugar content
Protein extractability

Lambrechts et al. (2026)

Oat enzymes and fermentation

- Fermentability of (non-)kilned oat suspensions





! Dominance of the inoculated strain was confirmed through culture-independent microbial analysis (16S rRNA sequencing)

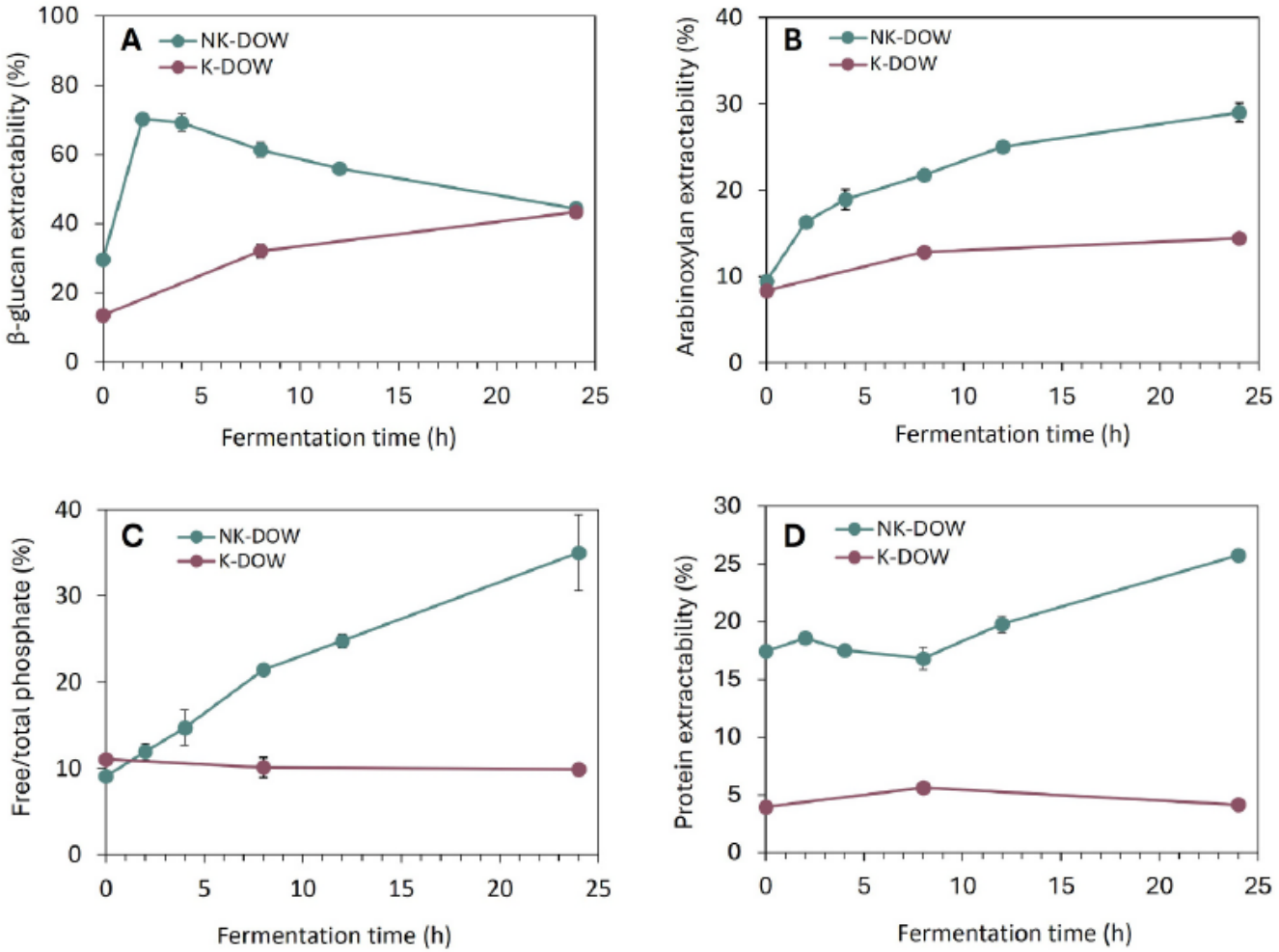
Main findings:

- The fermentability of kilned oats was much lower than that of non-kilned oats, likely due to a lack of oat endogenous enzymes

Lambrechts et al. (2026)

Oat enzymes and fermentation

- Effect of fermentation on oat constituent extractability

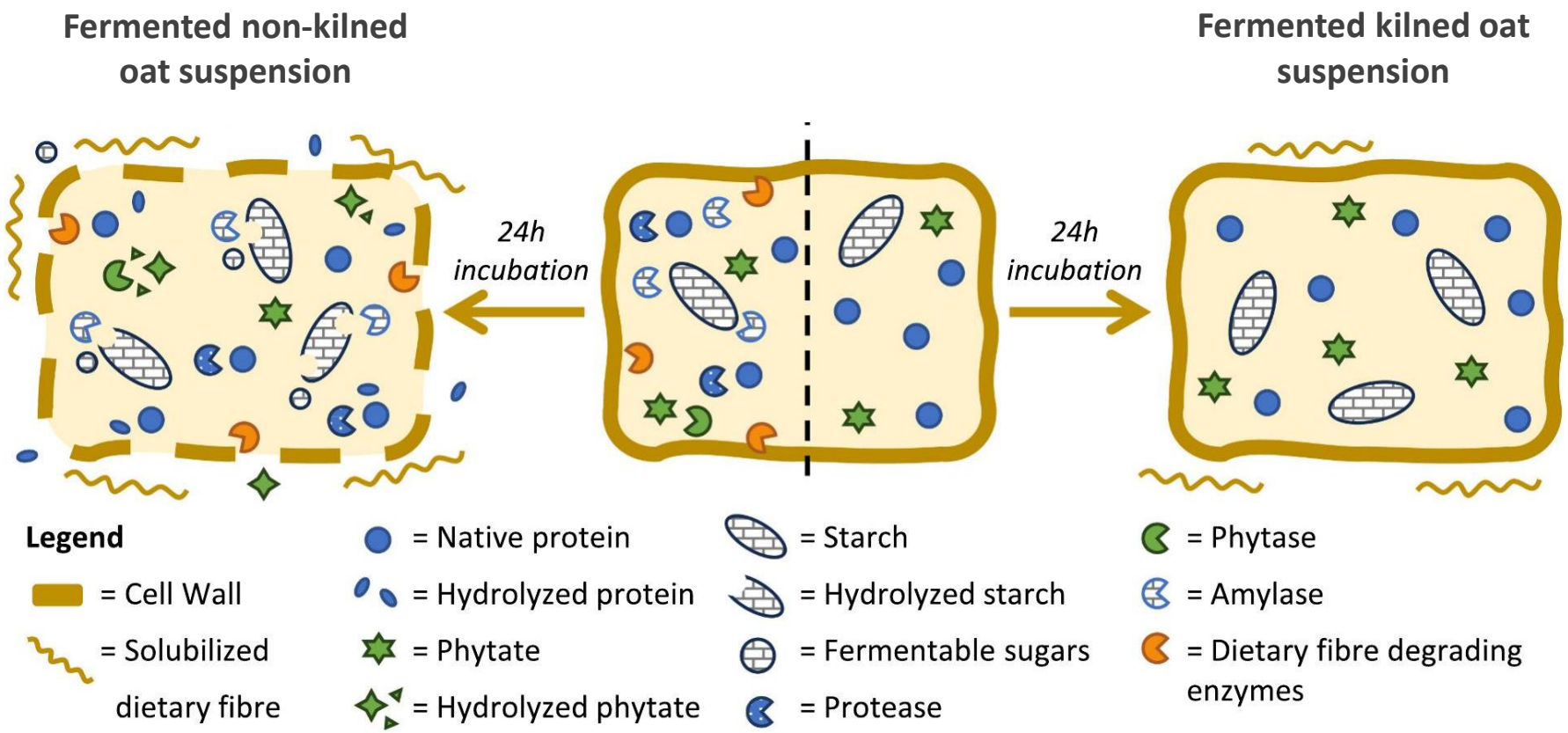


Main findings:

- Higer **lactic acid** production and faster **fermentable sugar** consumption in fermented non-kilned vs kilned whole meal suspensions
- Fermentation of non-kilned (but not kilned) oat wholemeal flour suspensions resulted in a large increase in the **arabinoxylan, β-glucan and protein extractability** and in a **reduction in phytate content**

Lambrechts et al. (2026)

Oat enzymes and fermentation



Blontrock et al. (2025)

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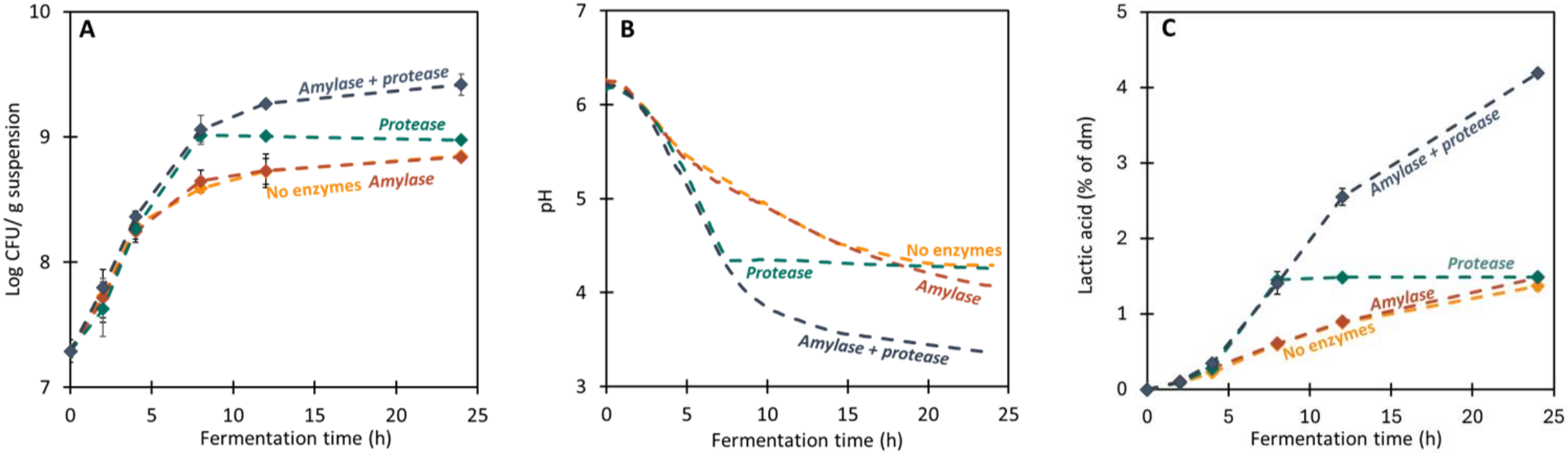
Oat fermentation and technofunctionality – What is the effect of acidic food fermentation on the technofunctional performance of an oat drink model food?

Li et al. (2025), Yang et al. (2023), Asschemann-Witzel et al. (2020), Montemurro et al. (2021)

Mitigating kilning

- Identification of kilning-induced hurdles for oat fermentability through enzyme addition



Main findings:

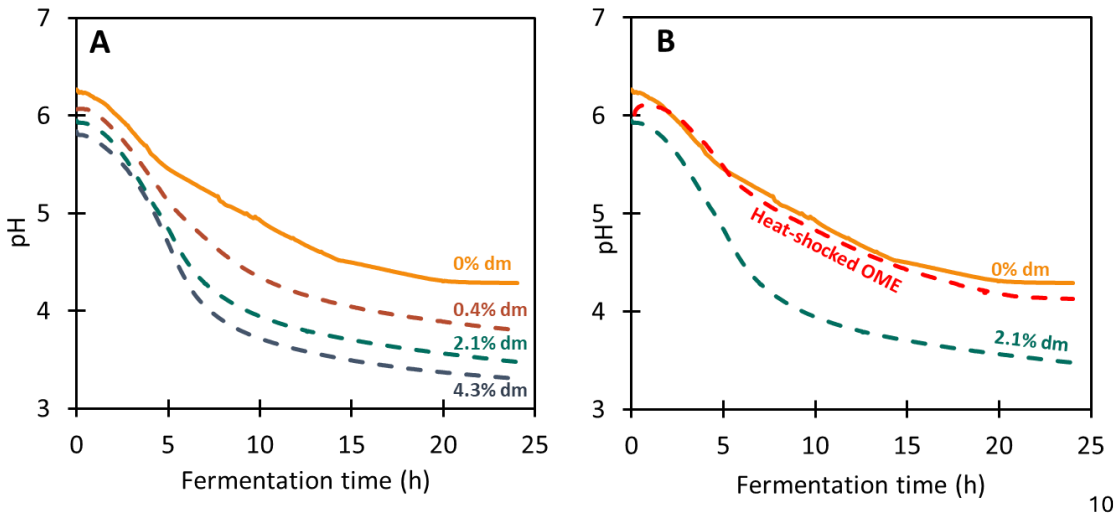
- Both amylase and protease are necessary to improve the fermentability of kilned oats.
- Protease addition improves the rate of acidification, while amylase addition improves the extent of acidification

Lambrechts et al. (submitted)

Mitigating kilning

- Oat malt extract as a source of oat endogenous enzymes

Kilned oat suspension fermentability

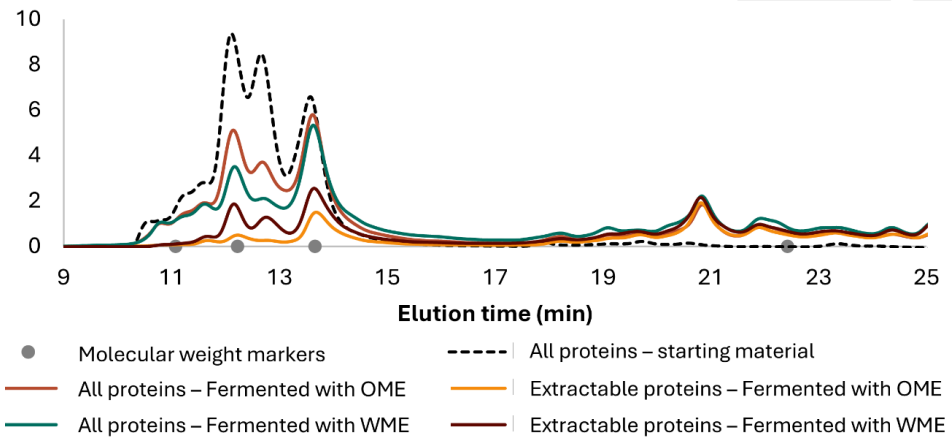


Impact on oat constituent extractability?

Main findings:

- Oat malt extract addition improves the fermentability of kilned oat suspensions
- Suprisingly, oat (and wheat) malt addition leads to increased extractability of non-hydrolysed oat proteins

Protein MW distribution in oat extracts



Lambrechts et al. (submitted); Blontrock et al. (submitted)

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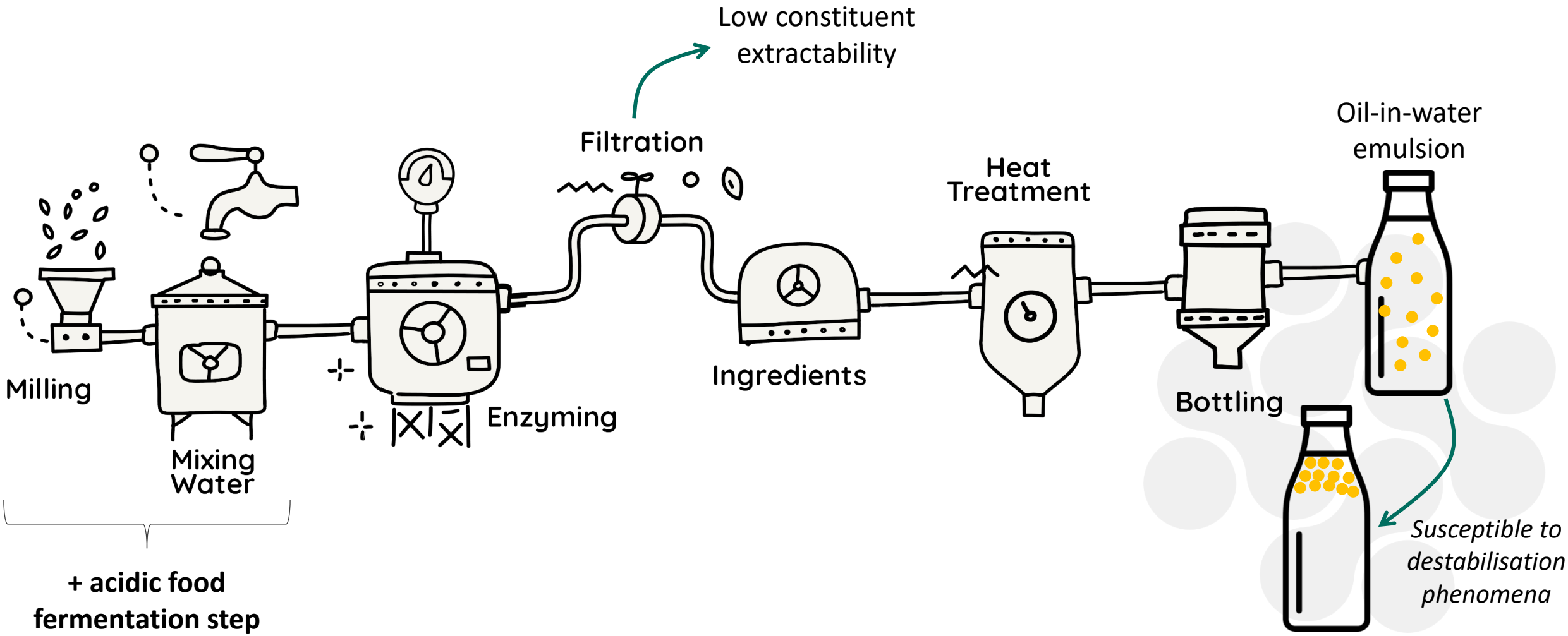
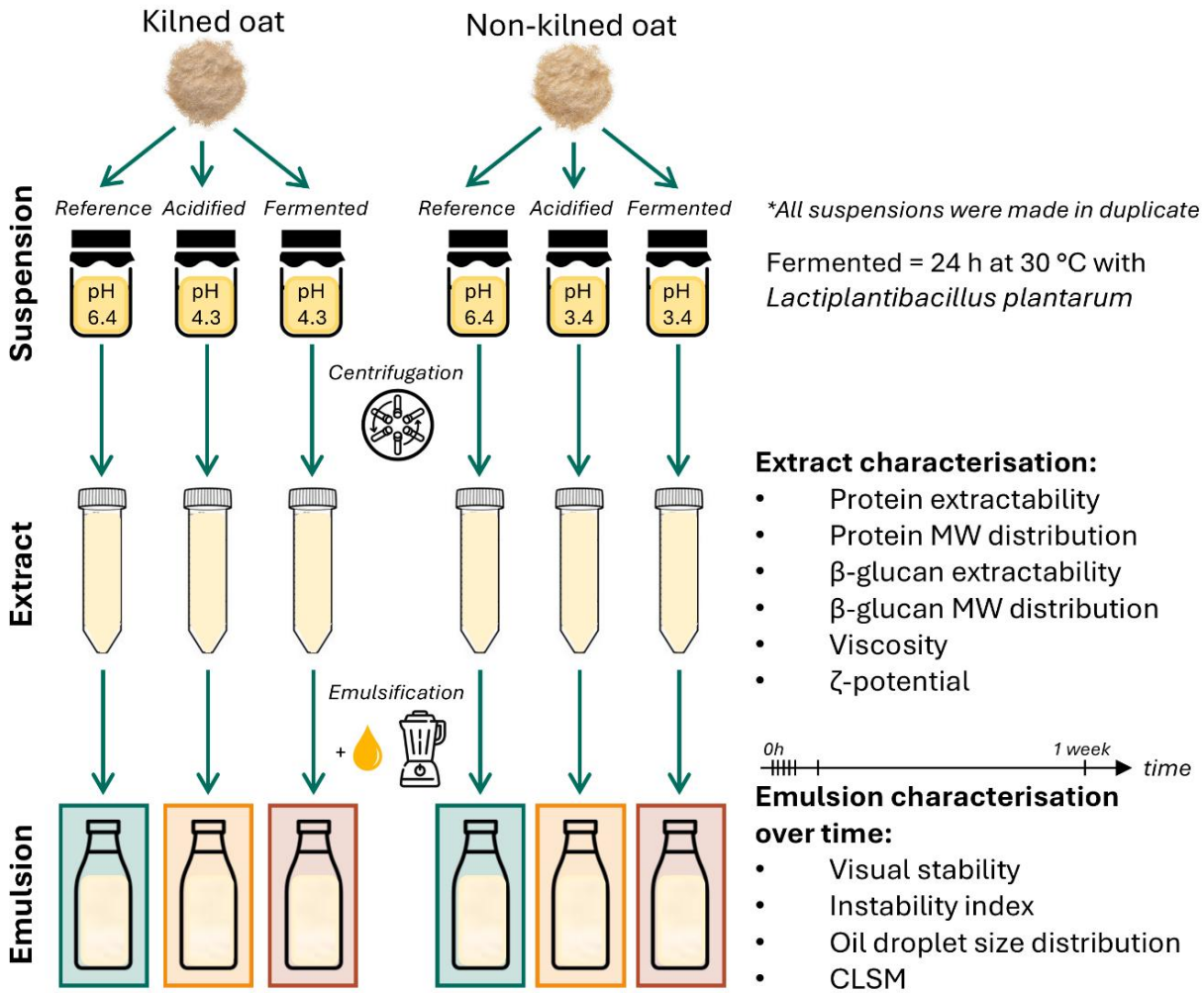
Oat fermentation and technofunctionality



Oat fermentation and technofunctionality

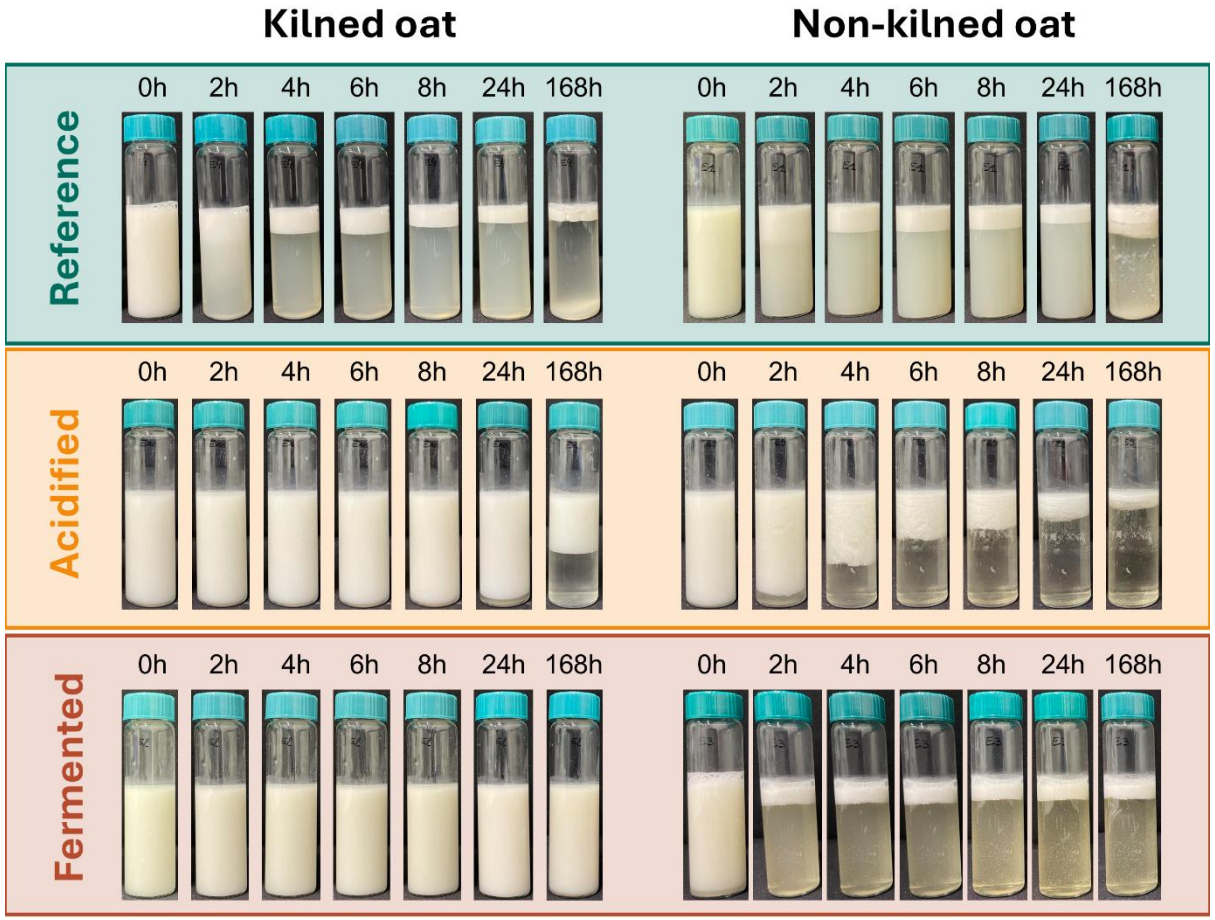
- Experimental set-up

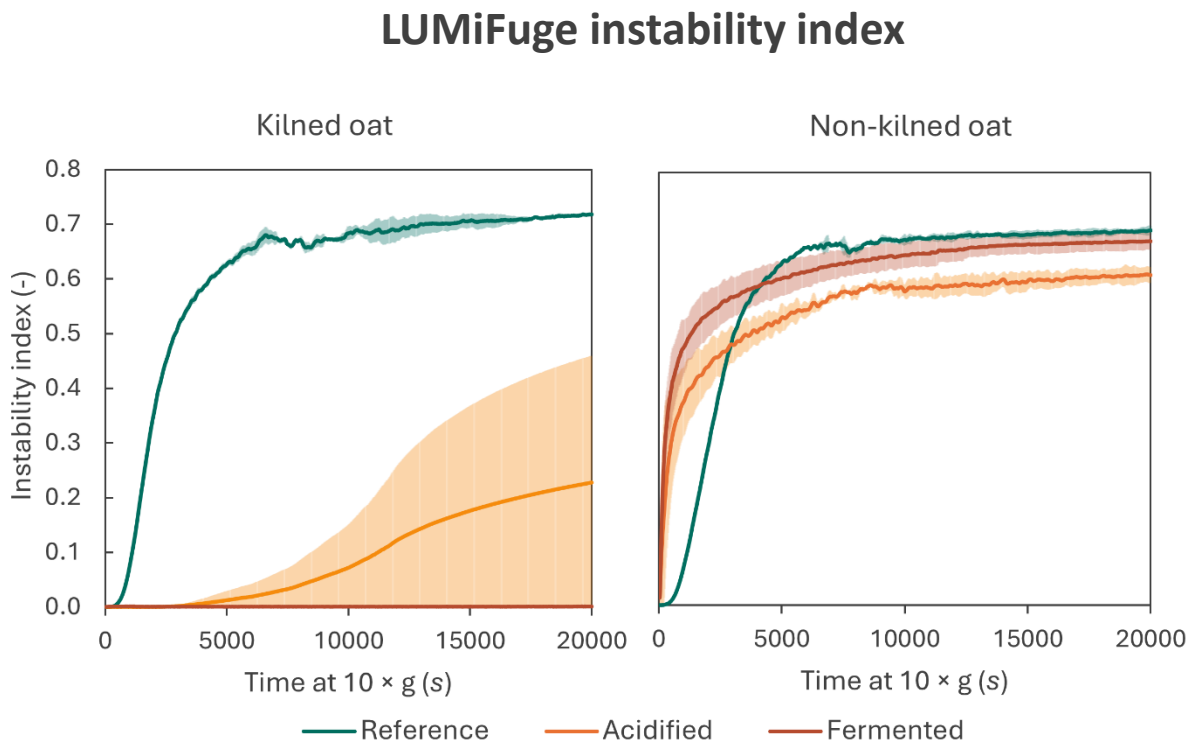


Blontrock et al. (in preparation)

Oat fermentation and technofunctionality

- Stability of oil-in-water emulsions against creaming





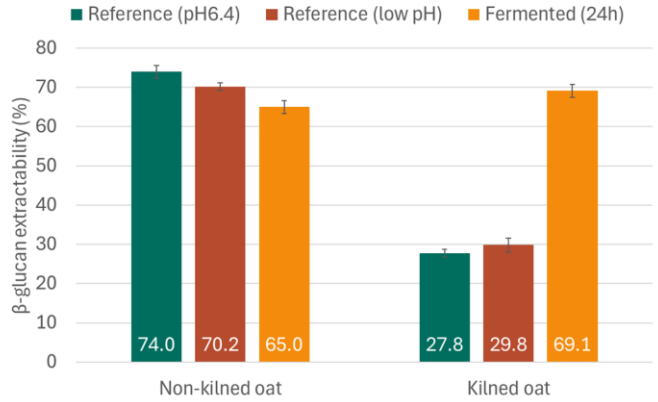
Blontrock et al. (in preparation)

Oat fermentation and technofunctionality

- Stability of oil-in-water emulsions against creaming

Extract relative viscosity

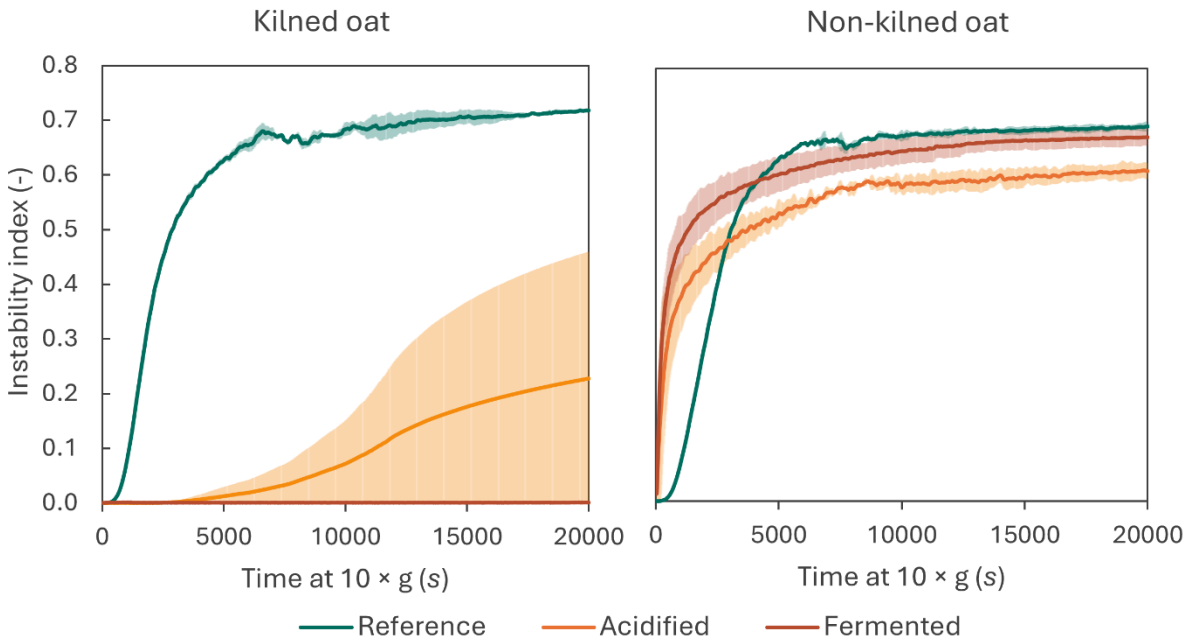
β-glucan extractability



Main findings:

- The composition and emulsifying properties of oat extracts can be tuned by prior kilning and acidic food fermentation
- High MW β-glucans, released through acidic food fermentation of kilned oats, can act as a 'clean-label' stabilizer in oat drinks

LUMiFuge instability index



Blontrock et al. (in preparation)

Conclusions and outlook

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- Basic insights into the fermentability of plant-based matrices allows for rationally designing food fermentation
- Comprehensive characterisation of fermentation-induced changes is necessary
- Food fermentation has the potential to improve the nutritional as well as technofunctional profile of oat-based foods

- Research is still necessary
  - Other food models and applications
  - Oat constituent digestibility and health-related characteristics
  - Microbial diversity, tuned towards the oat matrix, can be a real asset

Acknowledgements

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